NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
SOUTH DAKOTA SUPPLEMENTS ITALICIZED

TERRACE

(ft.)
CODE 600

DEFINITION

An earth embankment, a channel, or a combination ridge and channel constructed across the slope.

PURPOSE

This standard applies to the planning and design of all types of terraces. It does not apply to diversions.

To: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) improve water quality, (5) intercept and conduct surface runoff at a nonerosive velocity to a stable outlet, (6) retain runoff for moisture conservation, (7) prevent gully development, (8) reform the land surface, (9) improve formability, or (10) reduce flooding.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

1. Water erosion is a problem.
2. There is a need to conserve water.
3. The soils and topography are such that terraces can be constructed and farmed with reasonable effort.
4. A suitable outlet can be provided.
5. Runoff and sediment can damage land or improvements downstream or impair water quality.

Terraces will be planned and applied as part of the Resource Management System (RMS) where a combination of practices are used to protect the resource base as outlined in Section III of the South Dakota Technical Guide (SDTG). Contour farming is a major part of the RMS.

They shall not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance.

Basin and level parallel terraces shall be constructed on soils that are capable or absorbing and storing water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal is practicable and desirable.

Push-up terraces are most adaptable where land slopes exceed six percent and on loess soils in Land Resource Area 102B (SDTG, Section IB) where the loess mantle consistently equals or exceeds four feet on the slopes to be terraced.

PLANNING CONSIDERATIONS

Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability effects caused by seasonal or climatic changes.
3. Effects of snowcatch and melt on water budget components.
4. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.
5. Effects on the downstream or aquifers that could affect other water uses and users.
6. The effect on the water table of the field to ensure that it will provide a suitable rooting depth, field wide, for anticipated land uses.

7. Potential for water management to supply alternate uses.

Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the visual quality of onsite and downstream water.
4. Short-term and construction-related effects on the quality of onsite and downstream water.
5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration in soils that have restrictive layers.
6. Potential for uncovering or redistributing toxic materials such as saline soils.
7. Effects on the movement of dissolved substances below the root zone and to the ground water.
8. Effects on wetlands and water related wildlife habitats.

Spacing. The maximum spacing for terraces for erosion control shall be determined by one of the *two methods listed below:*

Terrace spacing should be adjusted so the farmable area will fit the landowner's present or anticipated future equipment. Consideration should also be given to maximum opportunity for changing row widths and even number of trips.

*The steepest significant land slope with in the terrace interval shall be used to determine the terrace spacing. The vertical interval from the high point of the area to be terraced to the top terrace may be increased to 1 1/2 times the normal vertical interval provided that the drainage area above the top terrace shall not exceed the drainage area between terraces of the same length.*In no case shall the maximum horizontal spacing exceed that shown in *Table 1* for the conditions shown. The maximum limits may not be exceeded when making the adjustments indicated below. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10 percent for terraces with underground outlets. The spacing *should* be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths. The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval.

For level terraces used for erosion control and water conservation, the spacing shall be determined as indicated earlier, but the maximum horizontal spacing shall not exceed 600 ft. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 3). For terraces on noncropland, the maximum spacing shall be governed by the capacity requirement.

Figure 1

Horizontal Interval for Steep Back-Slope Terraces

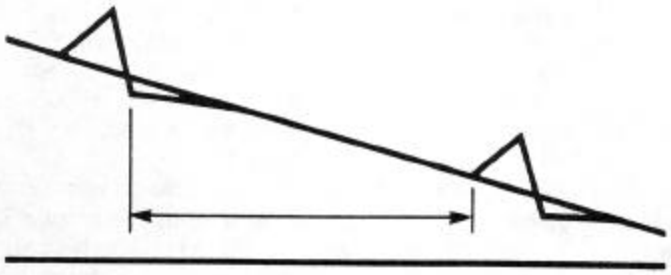

Figure 2

Horizontal Interval for Broad-Based Terraces

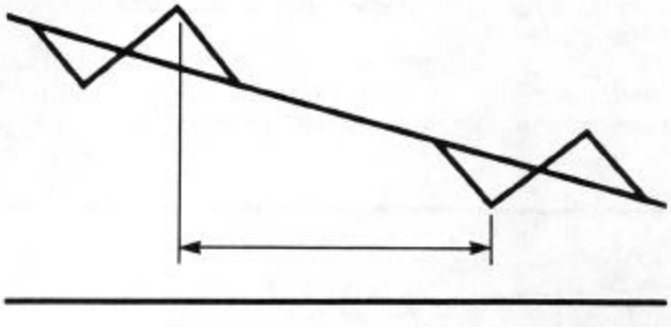

Figure 3

Terrace Spacing

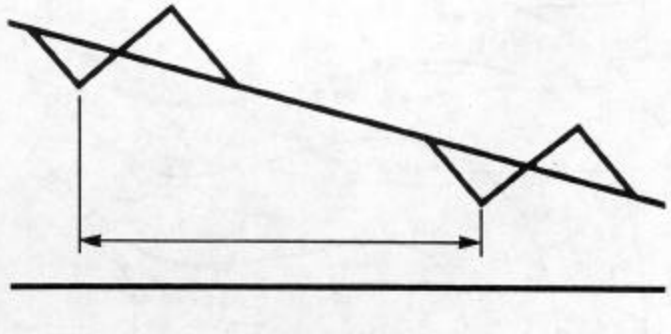

TABLE *1* - MAXIMUM HORIZONTAL SPACING FOR TERRACES

Slope	USLE R factor of			With contour stripcropping	For concentrated flow control
	0 - 35	35 - 175	More than 175		
Percent	ft	ft	ft	ft	ft
0 - 2	700	500	450	600	700
2 - 4	700	400	300	600	700
4 - 6	600	400	200	600	600
6 - 9	400	300	150	400	500
9 - 16	400	250	150	250	500
12 - 18	250	200	150	150	400
More than 18	250	200	150	150	300

In addition to the above maximum terrace spacing requirements, maximum terrace spacing must meet either of the following requirements:

1. Standard spacing:

Vertical interval = 0.8 S+Y

S= Land slope in feet per 100 feet.

Y= A variable with values from 1.0 to 4.0

Values of "Y" are influenced by soil erodibility, cropping systems, and crop management practices. A value of 1.0 shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. (Example: <10 percent ground cover and erodibility factor "K" >0.28.)

A value of 4.0 shall be selected for erosion-resistant soils with tillage systems that leave a large amount of cover. (Example: >80 percent ground cover and erodibility factor "K" <0.20.) A value of 2.5 shall be used if one of the factors is favorable and the other unfavorable or both are moderate.

(Example: <40 percent ground cover and 0.20 <K <0.24; <10 percent ground cover and K<0.20; >80 percent ground cover and K>0.24). Other value between 1.0 and 4.0 may be selected for use according to the estimated quality of other control factors within range given for "Y" of 1 to 4.

"Y" Values			
"K" / *Ground Cover*	*0-0.20*	*0.20-0.28*	*0.28-0.64*
10%	*2.5*	*	*1.0*
40%	*	*2.5*	*
80%	*4.0*	*	*2.5*
** values to be interpolated*			

TABLE 2

TERRACE SPACING

(As determined by the equation V.I. = 0.8S+Y), Horiz. Dist. = V. I. slope)

	Y = 1.0		*Y = 2.5*		*Y = 4.0*	
% Slope	*V.I.*	*Hor. Dist.*	*V.I.*	*Hor. Dist.*	*V.I.*	*Hor. Dist.*
1	*1.8*	*180*	*3.3*	*330*	-	*450***
2	*2.6*	*130*	*4.1*	*205*	*5.6*	*280*
3	*3.4*	*113*	*4.9*	*163*	*6.4*	*213*
4	*4.2*	*105*	*5.7*	*143*	*7.2*	*180*
5	*5.0*	*100*	*6.5*	*130*	*8.0*	*160*
6	*5.8*	*97**	*7.3*	*122*	*8.8*	*147*
7	*6.6*	*94**	*8.1*	*116*	*9.6*	*137*
8	*7.4*	*92**	*8.9*	*111*	*10.4*	*130*
9	*8.2*	*91**	*9.7*	*108*	*11.2*	*124*
10	*9.0*	*90**	*10.5*	*105*	*12.0*	*120*
11	*9.8*	*89**	*11.3*	*103*	*12.8*	*116*
12	*10.6*	*88**	*12.1*	*101*	*13.6*	*113*
13	*11.4*	*88**	*12.9*	*99**	*14.4*	*111*
14	*12.2*	*87**	*13.7*	*98**	*15.2*	*109*
15	*13.0*	*87**	*14.5*	*97**	*16.0*	*107*
16	*13.8*	*86**	*15.3*	*96**	*16.8*	*105*

**The spacing need not be less than 100 ft.*
***See page 4, USLE method of spacing.*

2. Revised Universal Soil Loss Equation (RUSLE) spacing. RUSLE may be used to determine maximum terrace spacing. The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor.

Alignment. Terraces shall be parallel if feasible and as parallel as practicable. Curves shall be long and gentle to accommodate farm machinery. Land forming, extra cut fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods shall be used to achieve good alignment.

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have adequate capacity to control a storm of a frequency consistent with the potential hazard. When the capacity is determined by the formula Q = AV and the V is calculated by using Manning's formula, an n value of 0.06 shall be used for bare channels; and SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation, or equivalent, shall be used for vegetated channels.

The required capacity must be contained with the effective height, measured between the points where both the channel and settled ridge have a width of three feet or more.

Cross section. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety. The ridge shall have a minimum width of 3 ft. at the design elevation. *Terrace side slopes constructed of unreinforced soil must meet the following requirements. Slopes must be 1 1/2:1 or flatter. Slopes 2 1/2:1 or steeper must be maintained with an erosion resistant vegetative cover following Critical Area Planting standard (342). Slopes 5:1 or flatter should be designed to efficiently accommodate the width of farm machinery to be used. Combined ratios of terrace front plus back slopes must be 4:1 or flatter.* The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

Terrace settlement*. All compacted terrace fills must have a minimum of 10 percent overfill to allow for settlement. Uncompacted fills must have 20 percent overfill.*

End closures. Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures shall be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water *capacity* flows over the end closure *in a noneroding manner,* before overtopping the terrace ridge. *End closures must be constructed with slopes that allow for machinery crossing.*

Partial end closures shall not be more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge.

Channel grade. Channel grade shall be determined by one of the following methods:

1. Maximum channel grade in the lower reaches of the channel shall not exceed 0.6 *feet per 100 feet of length.*
2. Maximum channel velocity for farmed channels *in* erosion-resistant soil is 2.5 ft/s (*K<0.20*); for average soils, 2.0 ft/s; and for easily erodible soils, 1.5 ft/s (*K>0.20*). Velocity shall be computed by Manning's formula, using an n value of 0.035.
3. Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

Channel grades may be uniform or variable. Channel velocity shall not exceed that which is nonerosive for the soil and planned treatment. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. If terraces have an underground outlet, water and sediment will pond in the channel, thus reducing the velocity and allowing steeper channel grades near the outlet. Minimum grades shall be such that ponding in the channel grades shall be such that ponding in the channel because of minor irregularities will not cause serious damage to crops or delay field operations.

Terrace length. The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft *on gentle slopes and 2,000 ft. on steep slopes* unless the channel is blocked at intervals *to provide these lengths.* Normally, the gradient terrace length is controlled by the capacity and the nonerosive velocity requirements. *For best results, graded terraces should move water less than 2,500 ft. in flat, smooth topography or 1,200 ft. in steep, gullied topography.*

Outlets. *Adequate outlets shall be provided for gradient or level terraces having open ends or partial end closures. Outlets may be a natural grassed waterway or vegetated area, an underground tile line, or permeable soil. Road ditches or rights-of-way will not be used as outlets. In all cases the outlet must convey runoff form the terrace system to a point where the outlet will not cause erosion.*

Combinations of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system. Acceptable outlet types and standards for their design, are as follows:

1. *Grassed waterways or surface outlets for level or gradient terraces, when needed, will be established before terrace construction to ensure vegetative cover in the outlet channel, except those constructed in the Eastern Technical Guide area.*

In the Eastern Technical Guide area, terrace outlets may be installed during terrace construction provided the standards for Critical Area Planting (342) and Mulching (484) is followed. The design elevation of the water surface in the terrace shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

The opening of the outlet end of open-end level terraces shall have a cross section at least equal to that specified for the channel of the terrace.

2. Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. An orifice plate, increase in conduit size, or other features shall be installed as needed to control the release rate and prevent excessive pressure when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, shall be such that a 10-year frequency, 24-hour storm will not overtop the terrace, and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops, depending on soils characteristics and water tolerance of crops to be grown.

The underground conduit shall meet the requirements specified for subsurface drains (606). Conduits must be installed deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet shall be located uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective, usually in well-drained soils.

3. Soil *with intake family 0.5 or greater* may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel with a reasonable period so that crops are not significantly damaged by standing water.

Vegetation. *All areas to be vegetated shall be established compatible with management objectives and the surrounding area as soon as practicable after construction according to Critical Area Planting standard (342).*

Chiseling, topsoil spreading, manure application, and fertilizing should be considered on all disturbed areas to bring cropland into high production as soon as possible. Weeds must be controlled to allow rapid grass establishment.

Selected species of grasses and woody plants should be considered for wildlife habit, in addition to wind and water erosion, as recommended in the practice standard for Wildlife Upland Habitat Management (645).

SAFETY AND MAINTENANCE

A program shall be established for maintaining terrace capacity, storage, ridge height, and outlets. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

Terrace ridges, especially those with steep back slopes, can be very hazardous. For this reason, some farmers prefer steep front slopes, thus keeping machinery away from the steep back slopes. All cut and fill slopes that are to be farmed must be no steeper than those on which farm equipment can operated safely. Any hazards must be brought to the attention of the responsible person. *Holes made by burrowing animals must be filled to prevent failure of the terrace.*

PLANS AND SPECIFICATIONS

Plans and specifications for installing terraces shall be in keeping with this standard and shall describe

the requirements for applying the practice to achieve its intended purpose.

CONSTRUCTION

All dead furrows, ditches, or gullies shall be filled before constructing the terrace or shall be part of the construction. All old, terraces, fence rows, hedge rows, trees, and other obstructions shall be removed, as necessary, to install a farmable system.

The terraces shall be constructed according to planned alignment, grade and cross section with the specified overfill for settlement and the channel graded to drain reasonably well.

Any ditch or depression at the bottom of the back slope shall be filled and smoothed so that drainage will be away from the terrace.

Provisions must be made to prevent piping if underground circuits are located under terrace ridges. Mechanical compaction, water packing, trench sidewall sloping, and installation and backfill of conduit trenches early enough to allow adequate settlement are methods that can be used. The materials used for the inlet and the conduit shall be suitable for the purpose intended (see standard 606). Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or by other suitable means to insure proper functioning of the terrace. *Where significant fill depths are needed for terrace alignment, additional fill must be provided for settlement.*

The surface of the finished terrace shall be reasonably smooth and present a workmanlike finish.

If necessary, topsoil shall be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

If vegetation is required, seedbed preparation, fertilizing, seeding, and mulching shall comply with specifications in Technical Guides.